ENGINEERING MAINTENANCE BRANCH BULLETIN

Issue # 009 *January 2006*

THIS MONTH'S BULLETIN CONTAINS:

- ***Picture of the Month***
- ***SAMM/Maintenance Tip***
- ***Precision Alignment: To Perform or Not Perform?***
- ***Question of the Month –Where Did My Oil Samples Go?***
- ***CMEO Training – What Are You Waiting For?***
- ***Help Us Help You! Dig Out Your Feedback!***
- ***Vibration Case Study: Sewage Effluent Pumps***

This is *the* monthly bulletin to MSC ships and shoreside personnel. The purpose of the bulletin is to inform all concerned of current COMSC Preventive Maintenance management practices associated with any new or revised policy and procedures, along with helpful tips & tricks for improved maintenance. The bulletin will also discuss and present any upcoming initiatives in the various programs.

We continue our efforts to bring you useful information with the page dedicated to the Vibration Monitoring System (VMS). This will have useful tips as well as past case histories.

PICTURE OF THE MONTH - WE NEED *YOUR* PICTURES!!

It is said, **"A picture's worth a thousand words!"** Let's prove it right. If you have pictures of Shipboard Maintenance (Vibration Monitoring, Oil Sampling, machinery upkeep, etc.) being performed, or a visit from a SAMM or VMS Tech Rep, please send them (along with a *brief* narrative as to what the picture is about) to Norm Wolf (e-mail: Norman.wolf@navy.mil).

Jason Diel of Seaworthy Systems, Inc. extracts a remote PENG database from the consolidated database server. The remote database is configured to communicate with the consolidated database via the Internet. This allows the Port Engineer to automatically back up the shipyard data to the consolidated database while performing the work on-site. Once the data has been uploaded to the consolidated database, they are able to share the information with other Engineers in MSC.

SAMM/Maintenance Tip

Documentation Tip Part 1 – Document "As Found" Condition:

Many shoreside or shipboard engineers make repair recommendations or create work orders for machines, but don't (or can't) follow up to see if the diagnosis was correct. This is unfortunate, as a great deal of valuable and educational information is lost. To avoid this, do whatever it takes to find out the "as found" condition when the machine is opened up for repair. This is often difficult to accomplish, but it is well worth the effort and in the best circumstances this should be implemented as a normal procedure. Also, accept that the original diagnosis may sometimes be wrong.

Ask for the replaced bearings, cut them open and look at the wear. If you have a digital camera, take a photograph. If a balance or alignment job was called for, ask for the 'before' and 'after' values. Retrieve and inspect gears and impellers and photograph them. This serves several purposes. The first is you will learn something, hone your skills and become a much better engineer. The second is you will be able to educate others and help prevent future problems. Third, all the information gathered can then be placed in a Machinery History entry for the piece of equipment in SAMM. Document lessons learned as well as your successes and you help yourself and others to be more successful engineers. You will also learn a great deal more about the machinery you are responsible for.

-Tip provided by DLI Engineering & MSC N711

PRECISION ALIGNMENT:

To Perform Or Not Perform?

(Norman Wolf, N711b Sr. Mech. Engr.)

In our first issue of the EMB Bulletin, we discussed the Heel and Toe effect of machinery alignment. In this issue we discuss the reasons for performing and the of advantages precision alignment.

What is shaft misalignment?

In very broad terms, shaft misalignment occurs when the centerlines of rotation of two (or more) machinery shafts are not in line with each other. As simple as that may sound there still exists a considerable amount of confusion to people who are just beginning to study this subject when trying to precisely define the amount of misalignment that may exist between two shafts flexibly or rigidly coupled together. How accurate does the alignment have to be? How do you measure misalignment when there are so many different coupling designs? Where should the misalignment be measured? Is it measured in terms of mils, degrees, millimeters of offset, arc seconds, or radians? When should the alignment be measured... when the machines are off-line or when they are running?

In more precise terms, shaft misalignment is the deviation of relative shaft position from a collinear axis of rotation measured at the points of power transmission when equipment is running at normal operating conditions.

What's the objective of precision alignment?

Simply stated, it is to increase the operating lifespan of rotating machinery. To achieve this goal, machinery components that are most likely to fail (e.g. bearings, seals, coupling, and shafts) must operate within their design limits. Accurately aligned machinery will achieve the following results:

- Reduce excessive axial and radial forces on the bearings to insure longer bearing life and rotor stability under dynamic operating conditions.
- Minimize the amount of shaft bending from the point of power transmission in the coupling to the coupling end bearing.
- Minimize the amount of wear in the coupling components.
- Reduce mechanical seal failure.
- Maintain proper internal rotor clearances.
- Eliminate the possibility of shaft failure from cyclic fatigue.
- Lower vibration levels in machine casings, bearing housings, and rotors (***Note:** frequently, slight amounts of misalignment may actually decrease vibration levels in machinery so be cautious about relating vibration with misalignment).

Why should you perform precision alignment?

There are a number of cost benefits of precision alignment. It can help reduce plant operating costs by reducing energy costs. Precision alignment also results in increased maintenance savings through reduced parts consumption and reduced overtime. Finally, it can help decrease equipment downtime and increase operating hours.

A study performed at the University of Tennessee found that even small amounts of misalignment could significantly reduce bearing life. The study found that if, on average, a motor was offset misaligned by 10% of the coupling manufacturer's allowable offset, there was a corresponding 10% reduction in inboard bearing life.

Furthermore, if a motor was offset misaligned by 70% of the coupling manufacturer's allowable offset, there was a corresponding 50% reduction in inboard bearing life (Hines et al). The results of the study are summarized in the table below.

OFFSET MISALIGNMENT AND INBOARD BEARING LIFE

Coupling Type	Maximum offset for 3 levels of expected bearing life			Maximum coupling offset recommended by manufacturer
	90% life expectancy	80% life expectancy	50% life expectancy	
Link	3 mils (12% max)	5 mils (19% max)	20 mils (77% max)	26 mils
Elastomeric	8 mils (11% max)	21 mils (30% max)	70 mils (100% max)	70 mils
Grid	1 mil (8% max)	2 mils (17% max)	5 mils (42% max)	12 mils
Gear	5 mils (10% max)	10 mils (20% max)	35 mils (70% max)	50 mils

An industry journal reports that precision alignment resulted in extending bearing life by a factor of eight in large class of rotating machines. Other reported benefits were a 7% savings in overall maintenance costs and a 12% increase in machine availability. Machine breakdowns attributed to misalignment were cut *in half*.

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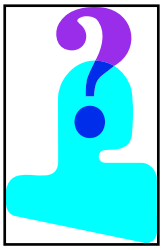

Question of the Month: Where Did My Oil Samples Go?

(From the Engineering Logistics Branch (N712))

Who do I send my machinery Lube Oil samples to? Why isn't it ExxonMobil any more?

Prior to January 2005, MSC had a five-year contract with ExxonMobil to perform used lube oil testing. MSC also had a separate contract with ExxonMobil to provide lubricants for the MSC fleet. These contracts had been separately competitively solicited. Due to concerns regarding the potential conflict of interest arising from ExxonMobil being responsible for both providing lubricants and analyzing the lubricants to determine when they needed to be replaced, the oil lab was only responsible for performing the analytical testing and reporting the results to MSC. MSC relied upon an in-house lube oil analyst to analyze the test results and provide recommendations to the fleet.

A replacement for the ExxonMobil lube oil analysis contract was competitively solicited in 2004 in anticipation of the ExxonMobil contract expiring in December 2004. A replacement five-year contract was awarded to Predict, a small business located in Cleveland, Ohio. Unlike ExxonMobil, Predict is not only responsible for performing analytical testing and reporting the results to MSC, but also analyzing the results and providing recommendations to MSC. MSC still relies upon an in-house analyst to review Predict's findings and recommendations prior to forwarding them to the fleet.

All lube oil samples should be sent to Predict at the following address using the pre-paid mailers that are available through the fuel and lube oil handling materials contract with Chase Supply.

PREDICT, INC
9555 Roadside Road
Suite 350
Cleveland, Ohio 44125
(216) 642-3223

MSC's used oil analysis program is constantly evolving and improving as we fine-tune our test slates and acceptance criteria to reflect lessons learned from our analysis program and feedback from our fleet. If you have any questions regarding the prepaid mailers or the fuel and lube oil handling materials contract in general or suggestions regarding improving the MSC used oil analysis program, or other comments, please contact Ed Guevara at (202) 685-5730 (edgardo.guevara@navy.mil) or Jason Halfhill at (202) 685-5737, (jason.halfhill@navy.mil).

Engineering Maintenance Branch Website – something old is new again!!

The Engineering Maintenance Branch web page continues to get a bit of a facelift; along with some helpful downloads (SAMM, PENG, EASy overviews, OAS Guide, ***past issues of our bulletin!***, etc.), the latest CMEO Class information and who to contact for questions or comments regarding Engineering. Maintenance. For helpful updates, keep checking it out!

http://www.msc.navy.mil/n7/engmgmt/engmgmt.htm

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Another benefit of precision alignment is a power saving. A recent study documented an average of 11% power saving by precision alignment in a group of simple pump-motor assemblies. This is because less power is expended in flexing the coupling, vibrating the machine, and heating the bearings. The dollar saving in this case due to reduced power consumption was more than twice the maintenance costs on these machines!

How often should alignment be checked?

Rotating machinery can move around immediately after it has been started. This is fairly rapid movement and the shafts eventually take a somewhat permanent position after the thermal and process conditions have stabilized (anywhere from 2 hours to a week in some cases). However there are slower, subtler changes that occur over longer periods of time. Machinery will slowly change its position for the same reason a driveway buckles, or a building foundation cracks. Settling of base materials underneath the machinery will cause entire foundations to shift. As the foundations slowly move, attached piping now begins to pull and tug on the machinery cases causing the equipment to go out of alignment. Operating environment temperature changes also cause base-plates, piping, and conduit to expand and contract.

In shoreside industries, on the average, shaft alignment on all equipment is checked on an annual basis. They also recommended that newly installed equipment be checked for any alignment changes anywhere from 3 to 6 months after operation has begun. Critical Equipment in SAMM is monitored through vibration monitoring and expert analysis. Since MSC vessels start and stop equipment much more frequently than the shoreside industry, machinery may have a tendency to become misaligned more frequently than within the shoreside experience.

ENGINEERING MAINTENANCE BRANCH BULLETIN

N711 – Points of Contact:
(cut it out & keep it handy!)

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CMEO Training – What Are YOU Waiting For????

CMEO (**C**IVILIAN **M**ARINE **E**NGINEERING **O**FFICER) is a two-week training course (held *quarterly*) at the Naval Supply Corps School in Athens, GA. It is for both shipboard and shoreside engineers. The Engineering Directorate (Code N7) of Military Sealift Command hosts the course and encourages ***ALL*** MSC Engineers (3rd A/Es through Chief Engineers, as well as Port Engineers and Project Engineers) to attend *(**Note:** MSC shipboard engineers are given priority when classes are full).*

CMEO provides training on an array of topics such as: SAMM (Condition Monitoring, Maintenance Scheduling and Repair, Diesel Engine Analysis, Logbook, etc.), Vibration Monitoring, Lube Oil, Fuel Oil (NEURS), Chemicals (boiler treatment, sewage treatment, etc.), Supply (COSAL, ShipCLIP), Environmental, and Safety. SAMM is interactively taught using actual data and each module is discussed extensively.

Upcoming CY '06 class dates:

- Jan 23-Feb 3, 2006 ←**Filled up!**
- April 17-28, 2006
- July 10-21, 2006
- December 04-15, 2006

For further information and to sign up, please go to the CMEO website:

http://63.219.124.12/cmeoclasssignup/cmeo.htm

Or contact Dave Greer (david.greer1@navy.mil) with any questions.

HELP US HELP YOU! DIG OUT YOUR FEEDBACK!

We've had more and more requests for the newsletters, from both shoreside AND shipboard engineers, so we know you're reading them. Now, tell us what you think! Feedback is *ESSENTIAL* to making this a helpful bulletin to all shipboard personnel in doing your job "smarter not harder". Please pass on ***any and all*** feedback from your Engine Department.

Not just Junk mail

JUNK MAIL: You don't want it; we don't want to create it. Make this ***YOUR*** Maintenance Management Bulletin. If there's a SAMM or Maintenance tip, topic, question, suggestion, or comment on how to make this useful, or something relating to Engineering Maintenance you think should get out to the ships, please pass it on. Send your submission to Randy Torfin (randel.torfin@navy.mil) *OR* Norm Wolf (norman.wolf@navy.mil).

COMING UP FOR *NEXT MONTH*!

New SAMM/Maintenance Tips!

More Maintenance Management Issues

Another Question of the Month

A New Picture of the Month!

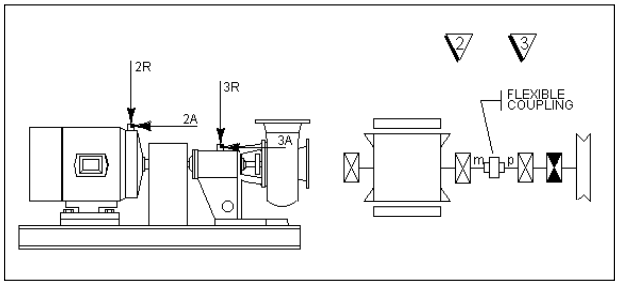
Vibration Monitoring Tips & Information

Vibration Analysis on Sewage Effluent Pumps

(Mike Johnson, PE, DLI Engineering Corp.)

The CMS (vibration) portion of SAMM 5.0 on USNS KANAWHA reported a serious motor bearing and/or coupling looseness along with a serious misalignment problem with No. 2 Sewage Effluent Pump in July of 1999. In early August they replaced the motor and performed an alignment on the shafts. On the post repair vibration test the CMS (vibration) still reported a misalignment. The Chief could not understand this diagnosis because he knew the coupling to be good and the alignment to be satisfactorily done. This case history explains why this happens on pumps like the Sewage Effluent Pump that moves liquid and solid waste.

The Sewage Effluent Pump on the T-AO class ships is a single stage centrifugal pump driven by a 5-hp. motor through a flexible coupling. The pump impeller has two vanes, which also act to macerate the solid waste. Here is the diagram and schematic shown in the Vibration Test and Analysis Guide (VTAG).



This machine is a very difficult one to apply automated vibration analysis to for the following three reasons:

1. The pump moves liquid that sometimes has solids mixed in. The hardness and concentration of these solids is not constant, leading to a sometimes quiet pump and sometimes noisy pump. When pumping liquid with some solids, the vibration levels all increase due to the impact of the solids with the impeller blades and pump casing. When pumping liquid w/o solids, the pump runs relatively quietly.
2. The impeller has two vanes so that for every shaft revolution we get two impacts. This creates vibration with a frequency equal to twice motor speed (we call this 2X). It is a coincidence that when offset (parallel) misalignment is present, vibration is also created at 2X. The automated diagnostics system has no way of knowing whether high 2X is from misalignment or solid waste excitation. The person collecting the data should be able to determine this by listening for solid waste excitation.
3. The average data (baseline) for this machine is built to reflect a fault free machine where very little vibration from pumping solid waste is present. This way the Expert Automated Diagnostic System (EADS) is sensitive to the majority of faults that can occur. If we were to average in data taken when the pump is moving solid waste, the average data amplitudes would be artificially high and the Expert System would under state (or miss completely) the severity of the common faults that occur.

After the post repair vibration test, the Chief reports that the "coupling looks in good condition and is properly aligned, but VMS again says it is not aligned". Given the three items above, it makes sense that while taking post repair data, the pump was pumping some solids, which made 2X amplitudes higher than the fleet average. Again, high 2X is the standard pattern for parallel misalignment. This is what likely triggered the misalignment diagnosis. The person collecting the data must confirm or deny this.

The Chief does not say what severity level the misalignment call is (slight, moderate, serious, extreme). A serious or extreme call should prompt another test where the test conditions are carefully monitored. The Chief does not mention whether he did a retest or what the test conditions were. Also he does not say whether he is getting the motor bearing looseness calls again. Good engineering practice dictates that the Chief has probably already done the retest and has answers to most of the above questions. Once all the data is put together, DLI can conclusively diagnose the machine from the office. Feel free to fwd data to DLI for review if not comfortable making a conclusion on your own.

In conclusion, this is a tricky machine to do vibration analysis due to the variability of test conditions. Sometimes the machine is pumping relatively soft solids and other times relatively hard solids. The Expert System is very sensitive to the vibration pattern and how it compares to the fleet average. The concepts in this case history apply to sewage pumps on all ships in the fleet. Most sewage pump impellers have either two or three vanes (cutters). Those with three vanes will not confuse the Expert System with parallel misalignment. Rather high 3X is indicative of a coupling looseness so you may see this automated diagnosis on sewage pumps with three vanes. Vibration analysis technology is not usually black and white. For the great majority of machines, the Expert System is exceptionally good at helping the fleet understand which shade of gray they are looking at.

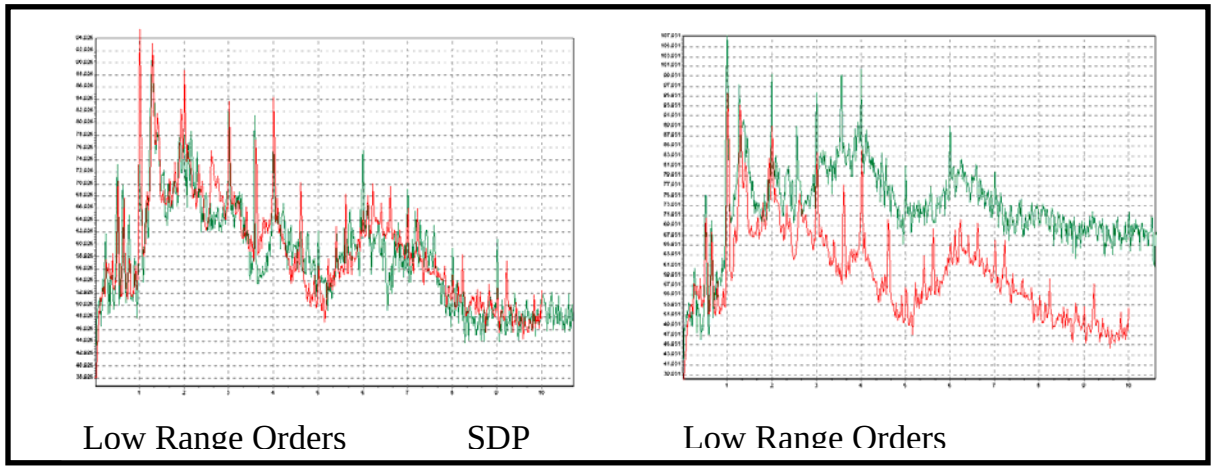


Figure 1. Axial spectra from Sanitary Pump #1 and Sanitary Pump #2. The green line is the current data and the red line is the average data. Note that the current data on SDP #2 is much higher than the average data.

SANITARY DISCHARGE PUMP #2

The data in Figure 1 clearly shows a much higher noise floor in the spectra on unit #2 than #1. In these plots, we are comparing the data to an average created from 24 fault-free Sanitary Discharge Pumps of the same model in exactly the same application. Pump #1 has spectra that are almost a mirror image of the Average data, while pump #2 has a noise floor that is higher than average and progressively increasing since overhaul in 97. You can think of the noise floor as a measure of the energy present.

Your Mark 1 Mod 0 visual and tactile inspection is very important to determine whether the difference in vibration is due to a machinery defect such as looseness or bearing wear, or due to the operating conditions. The Expert System gives you its best guess assuming it is a machinery defect.

In your email, you say that unit #2 may send some resonance or pulsation into the analysis. I'm not quite sure I understand what you mean here, however it sounds like you suspect that it is not a machinery defect. Doesn't SDP #1 pull from the same vacuum and discharge through a similar check valve? Is there a difference in the mounting? It is up to you to determine whether you want to live with this condition, however VMS will consistently diagnose a problem as long as the data is significantly above the average data.

If you are interested in looking at the trend, take a look at the axial (thrust) high range spectrum on SDP #2 with an Average overlay. Page through all the tests from 1995 to present. Now do the same thing with the data on SDP #1. If you do not have the training to do this, you are missing a very valuable skill in the use of VMS, in my humble opinion. If necessary, I can teach you this skill in about two minutes over the phone.

Recommendations:

MANDATORY: INVESTIGATE PUMP/FAN ELEMENT COUNT AND COMPARE TO DATA

DESIRABLE: BALANCE UNIT.

DESIRABLE: REPLACE BEARINGS

Faults: EXTREME PUMP INTERNAL WEAR OR LOOSENESS (UNSPECIFIED PUMP INFO) INDICATED BY:

- 103VdB 4X [2A] Exceedence: 17 VdB.
- 99 VdB 3X [2A] Exceedence: 13 VdB.
- 99 VdB 3X [2R] Exceedence: 10 VdB.
- 99 VdB 3X [2T] Exceedence: 9 VdB.
- 98 VdB 4X [2R] Exceedence: 17 VdB.
- 91 VdB 6X [2R] Exceedence: 24 VdB.
- 89 VdB 6X [2A] Exceedence: 20 VdB.
- 86 VdB 6X [2T] Exceedence: 17 VdB.
- 85 VdB 5X [2A] Exceedence: 27 VdB.
- 84 VdB 4X [2T] Exceedence: 5 VdB.
- 83 VdB 5X [2T] Exceedence: 21 VdB.
- 82 VdB 5X [2R] Exceedence: 15 VdB.
- 81 VdB 11X [2A] Exceedence: 13 VdB.

MODERATE MOTOR IMBALANCE INDICATED BY:

- 116 VdB 1X [2R] Exceedence: 21 VdB.
- 112 VdB 1X [2T] Exceedence: 18 VdB.
- 107 VdB 1X [2A] Exceedence: 10 VdB.

MODERATE BALL BEARING WEAR INDICATED BY:

- 99 VdB 3.6X [2A] Exceedence: 18 VdB.
- 95 VdB 3.6X [2T] Exceedence: 18 VdB.
- 92 VdB 3.6X [2R] Exceedence: 20 VdB.
- 55 VdB HR floor [2A] Exceedence: 7 VdB.
- 55 VdB HR floor [2R] Exceedence: 8 VdB.

SLIGHT BALL BEARING NOISE INDICATED BY:

- 55 VdB HR floor [2A] Exceedence: 7 VdB.
- 55 VdB HR floor [2R] Exceedence: 8 VdB.